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Date: September 9<sup>th</sup>, 2019

**Jennifer Szymanowski**

University of Notre Dame  
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**Subject: Notre Dame Plutonium Spectrum Analysis**

To Jennifer Szymanowski:

Gamma-ray spectra were acquired of a freshly prepared small sample of the plutonium in question at Notre Dame. The data was collected with a GammaX high-purity germanium (HPGe) detector.

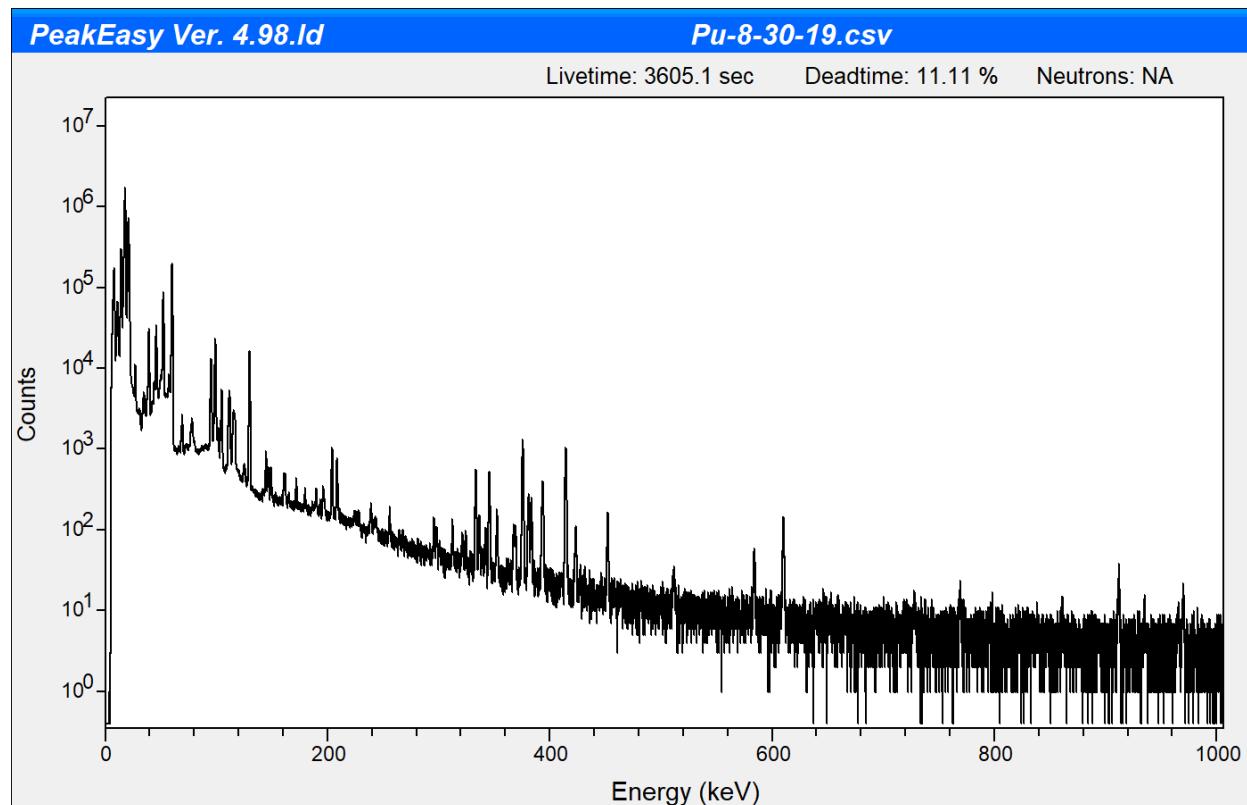


Figure 1: The gamma-ray spectrum of the plutonium item.

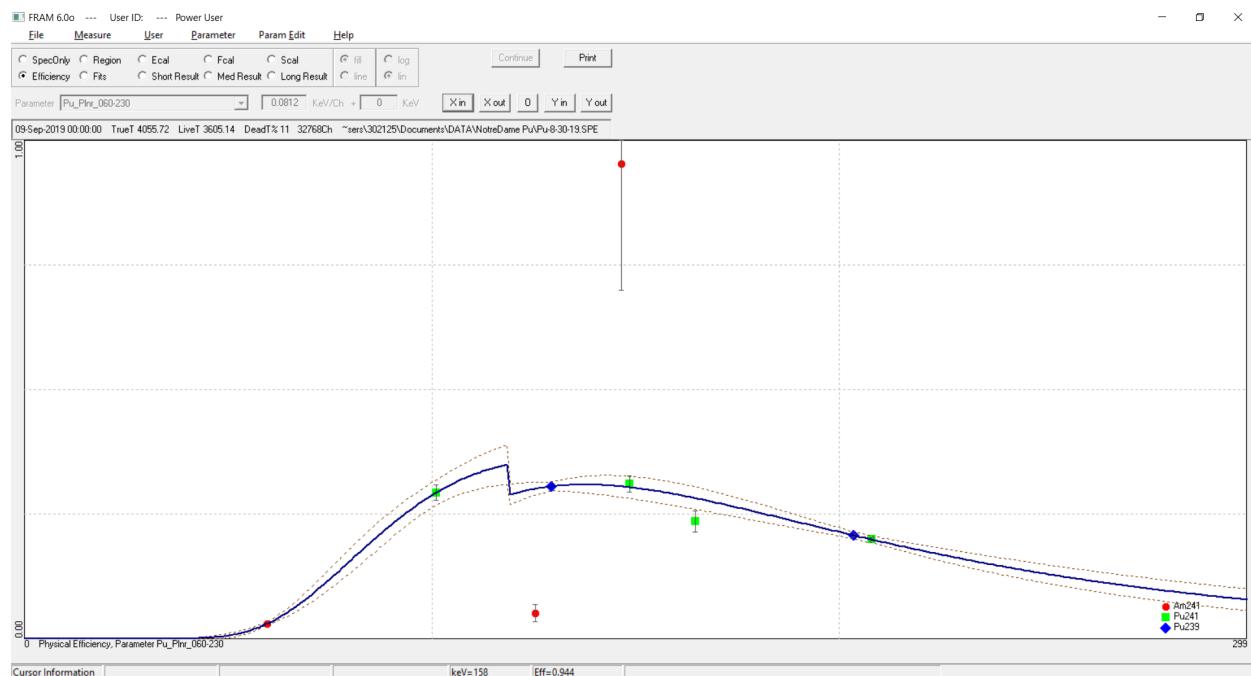
The spectrum was analyzed with the software FRAM (Fixed-Energy Response-Function Analysis with Multiple Efficiencies). Due to the excellent counting statistics in the low energy region due to the absence of shielding, the low energy parameter set ('Pu\_Plnr\_060-230') in FRAM was used; the parameter set defines an analysis region for peak fitting, efficiency modeling, and isotopic analysis.

All reported uncertainties and error bars are 1-sigma:

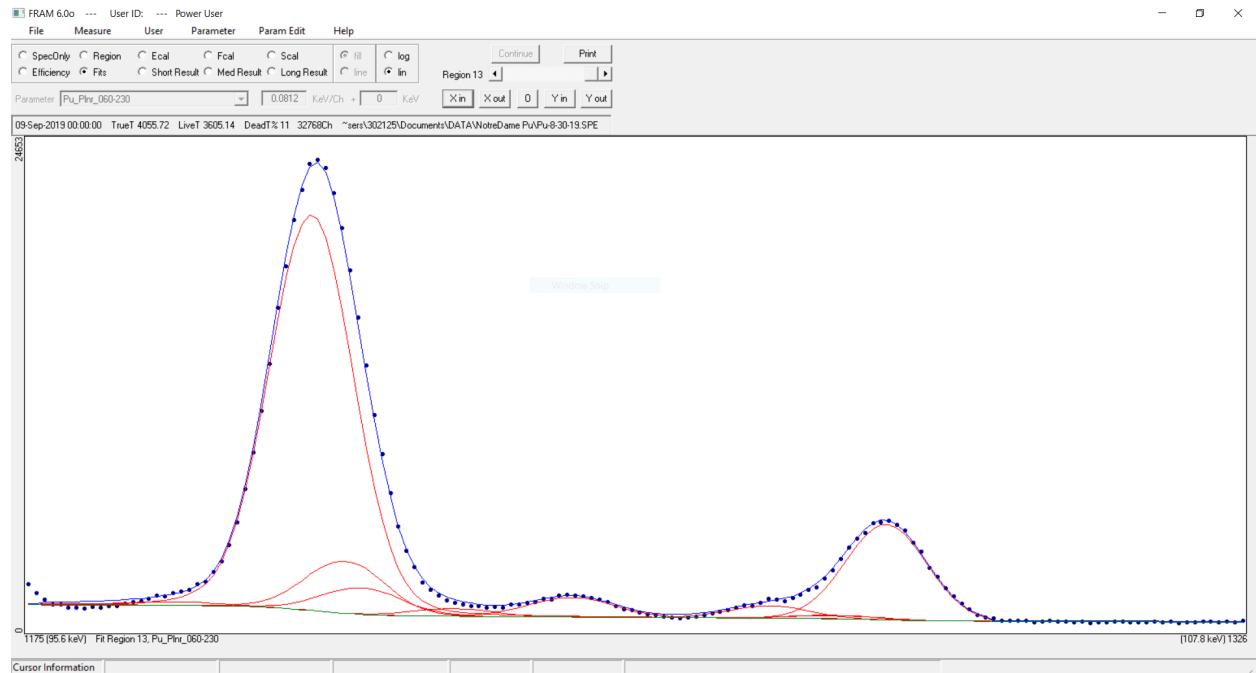
	Pu238	Pu239	Pu240	Pu241	Pu242	Am241
mass%	0.00778	93.62934	6.30353	0.0406	0.01875	0.03188
sigma	0.0012	0.54675	0.54513	0.0016	0.00359	0.04524
%RSD	15.43%	0.58%	8.65%	3.95%	19.12%	>99.99%

There are a few important points in these results. First, there is very low Am-241 content; peaks other than the 59.5 keV are not visible in the spectrum. This is consistent with recently processed plutonium items. Second, the Pu-242 content is estimated using a correlation function, described further in LA-UR-18-20605 (<https://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-18-20605>). In general, this approach is used for plutonium isotopic analysis because of the extremely weak gamma-ray signature of Pu-242.

For completeness, the efficiency curve and one of the fit regions are included here, in Figures 2 and 3. The quality of these two curves is indicative of the reliability of the analysis.



**Figure 2:** The relative efficiency curve fit by FRAM. Note that two of the Am-241 peaks (at 125.3 keV and 146.6 keV) have very large uncertainties due to the low number of counts in each of these peaks.



**Figure 3:** One of the regions used in the FRAM analysis, from 95.6 keV to 107.8 keV.

Jacob Stinnett, Ph.D.  
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PC FRAM (6.0o) Isotopic Analysis 17-Sep-2019 12:59:47  
(Fixed energy Response function Analysis with Multiple efficiencies)  
Operator ID:

spectrum source: C:\Users\302125\Documents\DATA\NotreDame Pu\Pu-8-30-19.SPE  
spectrum date: 17-Sep-2019 00:00:00  
live time: 3605.14 s  
true time: 4055.72 s  
num channels: 32768

parameter set: Pu Plnr 060-230 (2017.09.06 11:42)  
Pu Planar, Equilibrium, 60-230keV  
Physical Efficiency, Gain 0.0812 keV/ch, Offset 0.041 keV  
comment:

\*\*\*\*\*
\*\*\*\*\*  
at 59.536 keV, centroid = 731.752 [ 791.800 < ? < 795.800]  
at 208.000 keV, centroid = 2558.820 [ 2770.300 < ? < 2776.300]  
at 129.294 keV, fwhm = 961. ev [? < 800.]  
at 208.000 keV, low E tail %(fit-meas)/area = 1.485 +- 0.528 [? < 0.500]  
at 208.000 keV, high E tail %(meas-fit)/area = 1.644 +- 0.563 [? < 0.400]

					(By Corr)	%Am241/Pu
	Pu238	Pu239	Pu240	Pu241	Pu242	Am241
mass%	0.00778	93.62934	6.30353	0.04060	0.01875	0.03188
sigma	0.00120	0.54675	0.54513	0.00160	0.00359	0.04524
%RSD	15.43%	0.58%	8.65%	3.95%	19.12%	>99.99%

%TotPwr 1.89 77.36 19.12 0.06 < .01 1.56

Specific Power (W/gPu): ( 2.33435 +/- 0.06570)e-003 ( 2.81%)

Effective Pu240 fraction: ( 6.35463 +/- 0.54517)e-002 ( 8.58%)

Time since chemical separation: 4417.4 +/- 4790.5 days (>99.99%)

Relative mass ( U235 / Pu): 7.293e-003 ( 18.54%)  
Relative mass ( U238 / Pu): 7.016e-001 (>99.99%)  
Relative mass (Am243 / Pu): 8.828e-007 ( 16.63%)

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\*\*\*\*\*

#### Isotopic Results with Systematic errors included:

					(By Corr)	%Am241/Pu
	Pu238	Pu239	Pu240	Pu241	Pu242	Am241
mass%	0.00778	93.62934	6.30353	0.04060	0.01875	0.03188
sigma	0.00124	0.56320	0.56164	0.00186	0.00409	0.04524
%RSD	15.93%	0.60%	8.91%	4.58%	21.80%	>99.99%

%TotPwr 1.89 77.36 19.12 0.06 < .01 1.56

Specific Power (W/gPu): ( 2.33435 +/- 0.06648)e-003 ( 2.85%)

Effective Pu240 fraction: ( 6.35463 +/- 0.56169)e-002 ( 8.84%)

Time since chemical separation: 4417.4 +/- 4791.5 days (>99.99%)

Relative mass ( U235 / Pu): 7.293e-003 ( 18.54%)  
Relative mass ( U238 / Pu): 7.016e-001 (>99.99%)  
Relative mass (Am243 / Pu): 8.828e-007 ( 16.63%)

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\*\*\*\*\*

Table used for energy calibration:

	centroid	energy
-----		
1	731.752	59.536

2	1163.751	94.658
3	1590.141	129.294
4	1827.849	148.567
5	2558.823	208.000

\*\*\*\*\*

## FWHM parameter in the formula:

$$\text{fwhm} = \text{SQRT}( A1 + A2 * E + A3 / E )$$

A1 =	6.031e-001	sigma =	3.470e-002
A2 =	2.485e-003	sigma =	1.140e-003
A3 =	0.000e+000	sigma =	0.000e+000

Qfit = 5.812e+000    R\*\*2 = 0.99835    Cond = 2.336e+002

		interp.	fitted				
	energy	centroid	fwhm	fwhm	% rsd	formula	ratio
1	59.536	731.882	0.8831	0.8690	0.38%	0.8667	1.0027
2	94.658	1163.663	0.9510	0.8890	0.97%	0.9156	0.9709
3	129.294	1590.122	0.9852	0.9666	0.65%	0.9615	1.0053
4	148.567	1826.761	1.9667	1.7212	16.33%	0.9861	1.7456
5	208.000	2558.755	1.0616	1.1201	3.70%	1.0583	1.0584

\*\*\*\*\*

## Shape parameters in the formula:

$$\log(\text{tail}[i]/\text{hght}/\text{roll\_off}) = (T1+T2 * E) + (T3+T4 * E) * (\text{Ei}-E)$$

T1 =	2.209e+000	sigma =	9.637e+000
T2 =	-2.273e-002	sigma =	7.275e-002
T3 =	3.879e+000	sigma =	6.072e+000
T4 =	0.000e+000	sigma =	0.000e+000

Qfit = 4.075e+000    R\*\*2 = 0.82164    Cond = 9.697e+002

	energy	amp	slope
1	59.536	2.351606e+000	3.149667e-001
2	129.294	4.815567e-001	3.149667e-001
3	148.567	3.107177e-001	3.149667e-001
4	208.000	8.046129e-002	3.149667e-001

\*\*\*\*\*

## Calibration Diagnostics:

## check energy calibration:

1 at	59.536 keV, centroid =	731.752 [ 791.800 < ? < 795.800]
2 at	208.000 keV, centroid =	2558.820 [ 2770.300 < ? < 2776.300]

## check fwhm calibration:

3 at	129.294 keV, fwhm =	961. ev [? < 800.]
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## check shape calibration:

4 at	129.294 keV, tail fraction =	1.36 [? < 4.00]
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## check for interferences:

5 (	185.715, 203.545) peak area ratio = 0.031 +- 0.008 [? < 1.000]
6 (	228.140, 203.545) peak area ratio = 0.067 +- 0.007 [? < 0.500]

\*\*\*\*\*

## Summary of the results for each region:

region 1 from channel 1574 to 1603	( 128.000 keV to 130.300 keV)
------------------------------------	-------------------------------

```
-----  

total net counts =      210107.  

Qfit = 1.412e+000     R**2 = 0.99916    Cond = 1.000e+000  

pk isotope   energy   centroid   fwhm   tamp   tslp       area   % rsd   fn   factor  

--- --- --- --- --- --- --- ---  

33   Pu239   129.294  1590.141  11.841  0.482  0.315    210939  0.25%  1  1.0000  

-----
```

```
region 2 from channel 1529 to 1553      ( 124.400 keV to 126.200 keV)  

-----
```

```
total net counts =      533.  

Qfit = 4.243e-001     R**2 = -.20858    Cond = 1.000e+000  

pk isotope   energy   centroid   fwhm   tamp   tslp       area   % rsd   fn   factor  

--- --- --- --- --- --- --- ---  

30   Pu239   124.490  1531.001  11.764  0.537  0.315    2403   0.25%  0  0.0114  

31   Pu239   125.190  1539.619  11.775  0.529  0.315    2026   0.25%  0  0.0096  

32   Am241   125.292  1540.874  11.777  0.527  0.315    436    33.12% 1  1.0000  

-----
```

```
region 3 from channel 2271 to 2296      ( 184.600 keV to 186.600 keV)  

-----
```

```
total net counts =      437.  

Qfit = 4.060e-001     R**2 = 0.30086    Cond = 1.000e+000  

pk isotope   energy   centroid   fwhm   tamp   tslp       area   % rsd   fn   factor  

--- --- --- --- --- --- --- ---  

48   U235    185.715  2284.737  12.707  0.134  0.315    413    17.44% 1  1.0000  

-----
```

```
region 4 from channel 1790 to 1858      ( 145.500 keV to 151.000 keV)  

-----
```

```
total net counts =      6248.  

Qfit = 4.640e+000     R**2 = 0.71566    Cond = 1.021e+000  

pk isotope   energy   centroid   fwhm   tamp   tslp       area   % rsd   fn   factor  

--- --- --- --- --- --- --- ---  

38   Pu239   146.074  1797.101  12.105  0.329  0.315    3966  0.25%  0  0.0188  

39   Am241   146.557  1803.058  12.112  0.325  0.315    936   26.64% 1  1.0000  

40   Pu241   148.567  1827.849  12.144  0.311  0.315    4665  5.49%  2  1.0000  

41   Am241   150.113  1846.863  12.168  0.300  0.315    148   26.64% 1  0.1583  

42   U235    150.930  1856.912  12.180  0.294  0.315      1    17.44% 0  0.0017  

-----
```

```
region 5 from channel 1856 to 1890      ( 150.900 keV to 153.600 keV)  

-----
```

```
total net counts =      942.  

Qfit = 7.062e-001     R**2 = 0.11137    Cond = 1.000e+000  

pk isotope   energy   centroid   fwhm   tamp   tslp       area   % rsd   fn   factor  

--- --- --- --- --- --- --- ---  

42   U235    150.930  1856.912  12.180  0.294  0.315      1    17.44% 0  0.0017  

43   Pu238   152.720  1878.927  12.208  0.283  0.315    706   13.17% 1  1.0000  

-----
```

```
region 6 from channel 2005 to 2050      ( 163.000 keV to 166.600 keV)  

-----
```

```
total net counts =      871.
```

Qfit = 2.630e-001 R\*\*2 = 0.80990 Cond = 1.129e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
44	U235	163.360	2009.790	12.371	0.222	0.315	43	17.44%	0	0.1037
45	Am241	164.597	2025.004	12.390	0.216	0.315	7	33.12%	0	0.0156
46	Pu241	164.597	2025.004	12.390	0.216	0.315	868	9.04%	1	1.0000
47	Am241	165.930	2041.399	12.410	0.209	0.315	3	>99.99%	2	1.0000

-----  
region 7 from channel 2784 to 2822 ( 226.300 keV to 229.300 keV)  
-----

total net counts = 865.  
Qfit = 1.388e+000 R\*\*2 = -.08224 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
56	Am243	226.360	2784.932	13.296	0.053	0.315	16	14.29%	1	0.0265
57	Am243	228.160	2807.099	13.322	0.051	0.315	588	14.29%	1	1.0000

-----  
region 8 from channel 2487 to 2516 ( 202.200 keV to 204.500 keV)  
-----

total net counts = 12595.  
Qfit = 5.702e-001 R\*\*2 = 0.99295 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
50	Pu239	203.545	2504.031	12.969	0.089	0.315	12729	1.01%	1	1.0000
51	Am241	204.040	2510.119	12.976	0.088	0.315	0	33.12%	0	0.0005

-----  
region 9 from channel 2524 to 2581 ( 205.200 keV to 209.800 keV)  
-----

total net counts = 8485.  
Qfit = 9.454e-001 R\*\*2 = 0.98092 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
52	U235	205.311	2525.751	12.994	0.086	0.315	31	17.44%	0	0.0744
53	Am241	208.000	2558.823	13.033	0.080	0.315	55	33.12%	0	0.1253
54	Pu241	208.000	2558.823	13.033	0.080	0.315	8344	1.58%	1	1.0000
55	Am243	209.750	2580.375	13.059	0.077	0.315	223	14.29%	0	0.3799

-----  
region 10 from channel 722 to 740 ( 58.800 keV to 60.200 keV)  
-----

total net counts = 2121212.  
Qfit = 5.368e+002 R\*\*2 = 0.94362 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
1	Pu241	59.536	731.752	10.673	2.352	0.315	2044	1.58%	0	0.2450
2	Am241	59.536	731.752	10.673	2.352	0.315	2238482	0.36%	1	1.0000

-----  
region 11 from channel 1129 to 1173 ( 91.900 keV to 95.400 keV)  
-----

total net counts = 155518.  
Qfit = 1.987e+000 R\*\*2 = 0.99865 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
3	U235	92.290	1134.624	11.236	1.117	0.315	3	17.44%	0	0.0081
4	U238	92.368	1135.584	11.238	1.115	0.315	0	>99.99%	1	0.9856
5	U238	92.792	1140.799	11.245	1.104	0.315	0	>99.99%	1	1.0000
6	U235	93.358	1147.761	11.254	1.090	0.315	37	17.44%	0	0.0892
7		93.848	1153.788	11.263	1.078	0.315	560	91.60%	2	0.0034
8		94.658	1163.751	11.276	1.058	0.315	163854	0.34%	2	1.0000

-----  
region 12 from channel 1298 to 1319 ( 105.600 keV to 107.200 keV)  
-----

total net counts = 0.  
Qfit = 0.000e+000 R\*\*2 = 1.00000 Cond = 1.000e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
27	Am241	106.481	1309.299	11.472	0.809	0.315	0	>99.99%	1	1.0000

-----  
region 13 from channel 1177 to 1294 ( 95.800 keV to 105.200 keV)  
-----

total net counts = 356755.  
Qfit = 2.293e+000 R\*\*2 = 0.99819 Cond = 4.295e+000

pk	isotope	energy	centroid	fwhm	tamp	tslp	area	% rsd	fn	factor
9	Pu239	96.130	1181.872	11.301	1.023	0.315	637	0.25%	0	0.0030
10	Pu241	96.245	1183.288	11.303	1.021	0.315	10	19.59%	1	0.0039
11	Pu241	97.072	1193.468	11.316	1.002	0.315	2493	19.59%	1	1.0000
12		98.441	1210.322	11.339	0.971	0.315	265474	0.53%	2	1.0000
13		98.703	1213.547	11.343	0.965	0.315	0	>99.99%	4	0.0040
14	Pu239	98.780	1214.495	11.345	0.964	0.315	32172	0.25%	0	0.1525
15	Am241	98.951	1216.600	11.348	0.960	0.315	16326	6.63%	3	1.0000
16		99.541	1223.863	11.357	0.947	0.315	0	>99.99%	4	1.0000
17	Pu238	99.866	1227.864	11.363	0.940	0.315	4668	13.17%	0	6.6125
18	Pu241	101.066	1242.637	11.383	0.915	0.315	13159	4.91%	5	1.0000
19	Am241	101.066	1242.637	11.383	0.915	0.315	0	>99.99%	6	0.0990
20	Am241	102.040	1254.628	11.399	0.895	0.315	0	>99.99%	0	0.5933
21	Pu241	102.961	1265.966	11.414	0.876	0.315	4	1.48%	5	0.0003
22	Am241	102.961	1265.966	11.414	0.876	0.315	0	>99.99%	6	1.0000
23	Pu239	103.064	1267.234	11.416	0.874	0.315	7551	0.25%	0	0.0358
24	Pu241	103.672	1274.719	11.426	0.862	0.315	2194	1.48%	5	0.1667
25		103.748	1275.654	11.427	0.861	0.315	2306	21.18%	7	1.0000
26	Pu240	104.242	1281.736	11.435	0.851	0.315	59187	2.38%	8	1.0000

## Results of efficiency calculations:

coefficient	sigma
-4.48751e+000	2.04303e+000 (b : E^b)
-6.75979e-001	3.59291e-001 (ln(c) : c^(1/E))
1.55744e-001	1.03107e-001 (U/Pu g/cm2)
3.09888e-002	4.79136e-001 (Cd mm)
0.000000e+000	0.000000e+000 ( mm)
0.000000e+000	0.000000e+000 ( mm)
1.88884e+001	1.56616e+000 (Pu239)
1.85639e+001	1.56339e+000 (Pu241)
1.49168e+001	1.60452e+000 (Am241)

Chisq = 50.80

pk	isotope	energy	area	% rsd	branch	log(A/Br)	predicted	exp(dif)
----	---------	--------	------	-------	--------	-----------	-----------	----------

1	2	Am241	59.536	2238482	0.36%	3.5900e-001	15.646	15.646	1.0000
2	18	Pu241	101.066	13159	5.36%	5.6348e-006	21.571	21.572	0.9992
3	32	Am241	125.292	436	33.12%	4.0780e-005	16.184	17.951	0.1709
4	33	Pu239	129.294	210939	0.25%	6.2600e-005	21.938	21.938	1.0001
5	39	Am241	146.557	936	26.64%	4.7300e-006	19.103	17.965	3.1203
6	40	Pu241	148.567	4665	5.49%	1.8850e-006	21.629	21.607	1.0228
7	46	Pu241	164.597	868	9.04%	4.6140e-007	21.355	21.533	0.8373
8	50	Pu239	203.545	12729	1.01%	5.5800e-006	21.548	21.549	0.9988
9	54	Pu241	208.000	8344	1.58%	5.2500e-006	21.187	21.183	1.0036

isotope	beta
Pu239	0.00000
Pu241	0.00000
Am241	0.00000
Pu238	0.00000
Pu240	0.00000
Pu242	0.00000
U235	0.00000
U238	0.00000
Am243	0.00000

\*\*\*\*\*

#### Results of activity calculations:

isotope ratio	activity ratio	mass ratio	% rsd of numerator	isotope
Pu239/Pu239	1.00000e+000	1.00000e+000	2.247%	
Pu241/Pu239	7.22872e-001	4.33631e-004	3.297%	
Am241/Pu239	1.87850e-002	3.40540e-004	>99.999%	
Pu238/Pu239	2.29382e-002	8.30944e-005	15.273%	
Pu240/Pu239	2.46347e-001	6.73243e-002	8.952%	
Pu242/Pu239	0.00000e+000	0.00000e+000	>99.999%	
U235/Pu239	2.71484e-007	7.78915e-003	18.524%	
U238/Pu239	4.06189e-006	7.49305e-001	>99.999%	
Am243/Pu239	3.03478e-006	9.42884e-007	16.608%	

Qfit = 2.293e+000 R\*\*2 = 0.99819 Cond = 4.295e+000

#### Individual ratios:

pk	isotope	energy	area	% rsd	activity ratios	mass ratios
33	Pu239	129.294	210939	0.25%	1.00007e+000	1.00007e+000
50	Pu239	203.545	12729	1.01%	9.98824e-001	9.98824e-001
18	Pu241	101.066	13159	5.36%	7.22315e-001	4.33297e-004
40	Pu241	148.567	4665	5.49%	7.39381e-001	4.43534e-004
46	Pu241	164.597	868	9.04%	6.05286e-001	3.63094e-004
54	Pu241	208.000	8344	1.58%	7.25492e-001	4.35203e-004
32	Am241	125.292	436	33.12%	3.21971e-003	5.83678e-005
39	Am241	146.557	936	26.64%	5.87948e-002	1.06585e-003
43	Pu238	152.720	706	13.17%	2.29382e-002	8.30944e-005
26	Pu240	104.242	59187	2.38%	2.46347e-001	6.73243e-002
48	U235	185.715	413	17.44%	2.71484e-007	7.78915e-003
5	U238	92.792	283	>99.99%	4.06189e-006	7.49305e-001
57	Am243	228.160	588	14.29%	3.03478e-006	9.42884e-007

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## Summary of peak information:

pk	isotope	energy	area	% rsd	eff	hfac	mass ratios	
1	Pu241	59.536	2044	1.58%	0.3309	1.0000	4.3658e-004	F
2	Am241	59.536	2238482	0.36%	0.3309	1.0000	3.4159e-004	E QWT
3	U235	92.290	3	17.44%	2.6864	1.0000	7.3386e-003	F
4	U238	92.368	78	>99.99%	2.6919	1.0000	2.1054e-001	F
5	U238	92.792	283	>99.99%	2.7216	1.0000	7.4930e-001	A
6	U235	93.358	37	17.44%	2.7607	1.0000	7.3393e-003	F
7		93.848	560	91.60%	2.7941	1.0000	0.0000e+000	F
8		94.658	163854	0.34%	2.8483	1.0000	0.0000e+000	QW
9	Pu239	96.130	637	0.25%	2.9439	1.0000	9.4124e-001	F
10	Pu241	96.245	10	19.59%	2.9512	1.0000	1.3333e-004	F
11	Pu241	97.072	2493	19.59%	3.0028	1.0000	1.3335e-004	
12		98.441	265474	0.53%	3.0854	1.0000	0.0000e+000	
13		98.703	0	>99.99%	3.1008	1.0000	0.0000e+000	F
14	Pu239	98.780	32172	0.25%	3.1053	1.0000	9.4185e-001	F
15	Am241	98.951	16326	6.63%	3.1152	1.0000	4.8225e-004	
16		99.541	0	>99.99%	3.1490	1.0000	0.0000e+000	
17	Pu238	99.866	4668	13.17%	3.1673	1.0000	7.8512e-005	F
18	Pu241	101.066	13159	5.36%	3.2331	1.0000	4.3330e-004	EA
19	Am241	101.066	0	>99.99%	3.2331	1.0000	0.0000e+000	F
20	Am241	102.040	0	>99.99%	3.2843	1.0000	0.0000e+000	F
21	Pu241	102.961	4	1.48%	3.3308	1.0000	4.0719e-004	F
22	Am241	102.961	0	>99.99%	3.3308	1.0000	0.0000e+000	EA
23	Pu239	103.064	7551	0.25%	3.3359	1.0000	9.4317e-001	F
24	Pu241	103.672	2194	1.48%	3.3655	1.0000	4.0730e-004	F
25		103.748	2306	21.18%	3.3691	1.0000	0.0000e+000	
26	Pu240	104.242	59187	2.38%	3.3925	1.0000	6.7324e-002	A
27	Am241	106.481	0	>99.99%	3.4921	1.0000	0.0000e+000	
28	Am241	123.003	0	>99.99%	3.2782	1.0000	0.0000e+000	
29	Pu239	123.620	0	>99.99%	3.2898	1.0000	0.0000e+000	F
30	Pu239	124.490	2403	0.25%	3.3051	1.0000	1.0016e+000	F
31	Pu239	125.190	2026	0.25%	3.3166	1.0000	1.0014e+000	F
32	Am241	125.292	436	33.12%	3.3182	1.0000	5.8368e-005	EA
33	Pu239	129.294	210939	0.25%	3.3694	1.0000	1.0001e+000	EA QWT
34	Pu239	141.657	0	>99.99%	3.3983	1.0000	0.0000e+000	F
35	Pu239	143.350	0	>99.99%	3.3895	1.0000	0.0000e+000	F
36	U235	143.760	0	>99.99%	3.3870	1.0000	0.0000e+000	F
37	Pu239	144.211	0	>99.99%	3.3840	1.0000	0.0000e+000	
38	Pu239	146.074	3966	0.25%	3.3700	1.0000	9.9743e-001	F
39	Am241	146.557	936	26.64%	3.3659	1.0000	1.0658e-003	EA
40	Pu241	148.567	4665	5.49%	3.3469	1.0000	4.4353e-004	EA QWT
41	Am241	150.113	148	26.64%	3.3303	1.0000	1.0657e-003	F
42	U235	150.930	1	17.44%	3.3208	1.0000	7.7791e-003	F
43	Pu238	152.720	706	13.17%	3.2986	1.0000	8.3094e-005	A
44	U235	163.360	43	17.44%	3.1308	1.0000	7.7792e-003	F
45	Am241	164.597	7	33.12%	3.1081	1.0000	5.8130e-005	F
46	Pu241	164.597	868	9.04%	3.1081	1.0000	3.6309e-004	EA
47	Am241	165.930	3	>99.99%	3.0832	1.0000	7.3084e-005	
48	U235	185.715	413	17.44%	2.6704	1.0000	7.7891e-003	A
49	U235	202.110	0	>99.99%	2.3143	1.0000	0.0000e+000	F
50	Pu239	203.545	12729	1.01%	2.2839	1.0000	9.9882e-001	EA
51	Am241	204.040	0	33.12%	2.2734	1.0000	5.8291e-005	F
52	U235	205.311	31	17.44%	2.2467	1.0000	7.8019e-003	F
53	Am241	208.000	55	33.12%	2.1907	1.0000	5.8311e-005	F
54	Pu241	208.000	8344	1.58%	2.1907	1.0000	4.3520e-004	EA QWT
55	Am243	209.750	223	14.29%	2.1547	1.0000	9.4138e-007	F
56	Am243	226.360	16	14.29%	1.8323	1.0000	9.4274e-007	F
57	Am243	228.160	588	14.29%	1.7997	1.0000	9.4288e-007	A

Efficiencies are divided by 1.0e+009

E - this peak is used to determine relative efficiencies.

A - this peak is used to determine relative activities.

F - this peak is fixed to another peak.

S - this peak is summed with another peak.

Q - this peak is used to determine the energy calibration.

W - this peak is used to determine the fwhm calibration.

T - this peak is used to determine the shape calibration.

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Check sample types:

1 ( 148.567, 164.597) mass ratio = 1.222 +- 0.129 [ 0.900 < ? < 1.100]

check low energy tail of peak fit:

1 at 59.536 keV, low E tail %(fit-meas)/area = 0.514 +- 0.013 [? < 0.500]  
2 at 129.294 keV, low E tail %(meas-fit)/area = 0.079 +- 0.057 [? < 0.500]  
3 at 208.000 keV, low E tail %(fit-meas)/area = 1.485 +- 0.528 [? < 0.500]

check high energy tail of peak fit:

2 at 129.294 keV, high E tail %(meas-fit)/area = 0.127 +- 0.053 [? < 0.400]  
3 at 208.000 keV, high E tail %(meas-fit)/area = 1.644 +- 0.563 [? < 0.400]